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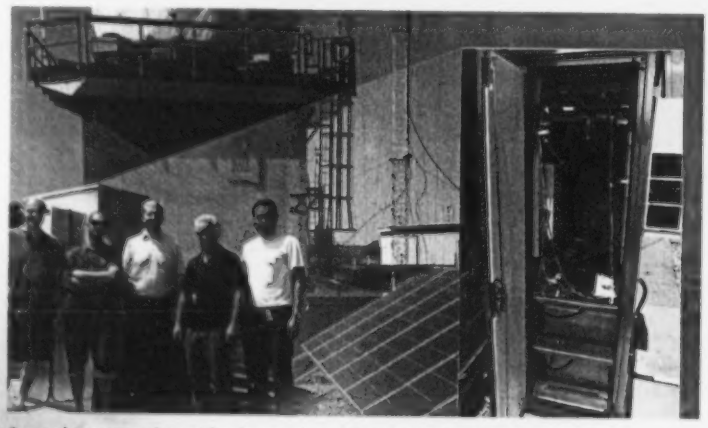
Green ICT field grows at CRC

The information and communications technologies (ICT) sector is currently responsible for two to three percent of global carbon dioxide emissions, which is roughly equivalent to the emissions of the entire aviation industry. In addition, ICT emissions are growing faster than any other sector in society, doubling every four years[1]. As fast as ICT has expanded over the last quarter-century, the field of "Green ICT" is starting to play catch-up. Broadband's potential to reduce greenhouse gas emissions is, after all, promising.

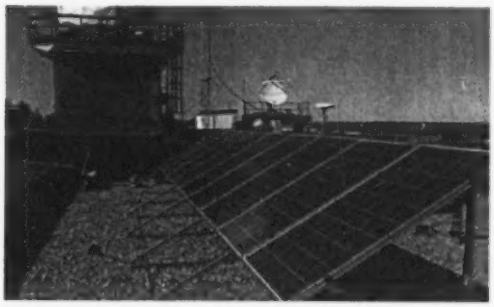
At the Communications Research Centre (CRC) in Ottawa, researchers are working with Canada's Advanced Research and Innovation Network (CANARIE), lead partner École de technologie supérieure (ÉTS) and other collaborators to explore more sustainable methods for fuelling ICT and test their practical applications. Under the CANARIE Green IT Pilot Program, CRC has begun testing the viability of two eco-friendly alternatives: the GreenStar Network and IT relocation.



Research team members with solar panels and GreenStar Network equipment (inset).

[1] CANARIE – ICT and Climate Change, Benefits to Canada
http://www.ottawaresearch.com/media_lib/PDF_Documents/actibredkfastjune2409062409194 8plspppt01.pdf
http://www.greenstarnetwork.com

Both of these projects aim to increase the use of renewable energy by shifting data to where it can be processed with a sustainable power supply. This concept is parallel with the idea of cloud computing, wherein users access centralized services over networks as they need them, similar to a utility.



Eight-panel solar array on the roof of a building at CRC

"We're trying to maximize the use of lower cost renewable energy by moving jobs across a shared virtualized IT infrastructure to nodes where sun or wind generated power is available," says Michel Savoie, Research Program Manager of CRC's Broadband Applications and Optical Networks group.

GreenStar Network

With a solar node installed on its roof, CRC is an integral partner in the production of the world's first network powered solely by renewable energy sources, including solar and wind energy. Under the guidance of CANARIE, this network, known as the GreenStar Network (GSN), connects a solar powered node at CRC with other renewable energy powered nodes both nationally and internationally. While still in the testing stages, this type of network may provide a vast array of opportunities for the reduction of future dependence on non-renewable energy sources.

The GSN operates by migrating jobs to those nodes that are currently being powered. As the Earth rotates and different areas experience daylight, for example, different nodes in the network generate the most energy. These powered nodes may then accept the live migration of jobs from other nodes in the network. This is referred to as a "follow the sun" or "follow the wind" network architecture. Correspondingly, if the demand for energy does not reach the energy being generated over the GSN, batteries store any excess energy for future consumption.

Along with its roof-top solar powered node, CRC is working on the network infrastructure, ensuring proper connectivity between all of the nodes and the seamless migration of data over the GSN. Partnering with the Synchromedia team at ÉTS, CRC is working on a software, known as "middleware", based on the Infrastructure as a Service Framework that will be able to manage the GSN, balancing inputs such as network usage and number of jobs with the weather at all of the nodes to direct the transfer of necessary information.

IT Relocation

CRC is investigating the energy requirements to run large-scale IT equipment and the possibility for a cleaner energy source to be used to meet the high demands. Partnering with the Grid Research Centre (GRC) at the University of Calgary, researchers are examining the servers used to support GRC's GeoChronos platform on site. Following inspection, all of the server information will be moved off site to RackForce's data centre in Kelowna, B.C., which is powered by an adjacent hydro dam.

By comparing the energy used at the GRC and at the "greener" data centre, the researchers hope to be able to analyze how many tons of carbon emissions have been saved over a year and, as a result, the carbon credits generated for sale. It is this groundbreaking application of carbon

accounting in the ICT sector from which CRC and its partners hope to develop a general carbon protocol for ICT equipment in conjunction with the Canadian Standards Association. Currently, no standards exist in the International Organization for Standardization regarding carbon emissions and ICT.

The Future

Both of these innovative projects are in their infancy. If proven successful, CRC and its partners may then begin to implement these projects on larger scales. The GSN could be used to link industry, universities and government worldwide, all while adding power to the electricity grid.

"As part of the project we will be looking at the scaling issues," says Savoie. "If our outcomes are positive, CANARIE has already asked us to consider how to implement these systems in their network."

At CRC, additional opportunities exist on the 600-hectare Shirleys Bay campus to harness more renewable energy.

"What we've done right now for this pilot project is establish a two-kilowatt solar power system," says Savoie. "What we would like to see down the road is if CRC could take the lead for the federal government. With the land on the campus, CRC could set up a solar farm and put in place a green cloud, thereby allowing the hosting of jobs from other government departments. Our green cloud could reduce dependence on non-renewable energy."

As the ideas and concepts of the Green ICT field grow, Savoie adds that the IT sector has the potential to reverse its trend in non-renewable energy consumption.

"The demand for IT continues to increase and thereby the power being consumed continues to increase. We are a big contributor to carbon emissions, however, there is merit in IT also being used to reduce carbon emissions."

For more information contact Michel Savoie, Research Manager, Broadband Applications and Optical Networks, at 613-998-2489 or *michel.savoie@crc.gc.ca*.

Bringing green solutions to life – CRC bolsters business case for next generation networks

Next generation networks (NGN), whether Long Term Evolution (LTE) or WiMAX, offer consumers a future in which tens of billions of mobile devices – such as smart phones, laptops, mobile Internet data sticks and even televisions – will be connected to a single Internet Protocol network that is accessible anywhere and at any time.

The insatiable consumer appetite for higher performance mobile broadband is not without its challenges, however. Spectrum is finite and over the next five years, mobile broadband traffic is expected to increase 35-fold. For government policy makers and regulators, this challenge and the value of spectrum are well known. One solution is to explore innovative ways to use it more efficiently.

The Communications Research Centre (CRC) conducts leading-edge applied R&D into next generation network technologies such as LTE and WiMAX. This R&D is used to advise Industry Canada on effective and efficient use of the radio spectrum. A byproduct of the R&D is insight that can aid Canadian industry as it ushers in the era of mobile broadband.

A recent CRC analysis found that maintaining an LTE network could be far more expensive over the 10-year lifespan of the network than the upfront costs of building one, despite LTE's promise of improved cost efficiencies. According to CRC's

calculations, operating expenses could exceed capital expenditures by four to ten times.

"This is a critical challenge for carriers. They need to find ways to operate these new networks in a cost effective way to maintain their profitability while meeting consumer demands for bandwidth-intensive downloads like high-definition video," says Dr. Alex Vukovic, Vice-President of CRC's Terrestrial Wireless Systems Research branch.

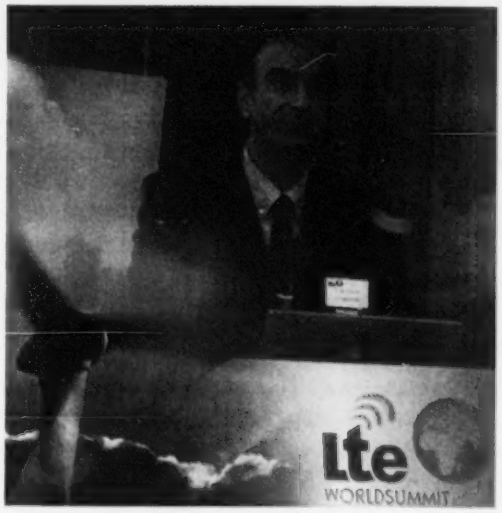
Fortunately, CRC's sobering prediction also comes with potential solutions that, if fully implemented, could reduce those operating costs by as much as 40 percent.

"Our analysis was based on creating the most efficient and cost-effective network," explains Vukovic. "The solutions are to marry green technologies based on alternative energy sources and opportunities to reduce the costs, either by improving the design of the equipment or different site configuration or changes in the overall wireless network architecture."

Vukovic presented CRC's findings at the 6th LTE World Summit, held in Amsterdam in May – the largest conference in the world focused on LTE. His presentation, entitled "Strategies for Green and Cost-Effective LTE Network," was based on consultations with several wireless carriers. The presentation caught the attention of a Green Radio consortium, led by the U.K. and European Union, that invited CRC to join them in developing green solutions for next generation radios.

Green solutions can save carriers money

The CRC study found that energy alone makes up 22 percent of all operational costs for an LTE network. The other big operating expense is maintenance (27 percent). CRC identified several areas where companies can save money, including adopting energy-wise strategies that use renewable energy (e.g. solar and wind), and by carefully choosing the right equipment, site configuration and network design.



Dr. Alex Vukovic, Vice-President of CRC's Terrestrial Wireless Systems Research branch, at LTE World Summit 2010

"The first step is to try to understand the unique challenges of each carrier and then to come up with cost-saving solutions that meet their particular goals and business case. It's not a one-size-fits-all solution," explains Vukovic.

For example, using nanomaterials and next generation power amplifiers can reduce the size, weight and power consumption of some radio equipment. Likewise, low-voltage processors and traffic management software can cut the power requirements of digital equipment in an LTE network. Installing radio equipment at the top of a wireless tower, as opposed to the base, also means less power is needed for transmissions to the feeder cables and to cool equipment.

Other green solutions include: software that can idle or partially shutdown systems during low-traffic periods, and tower-sharing arrangements amongst carriers to avoid duplication of new construction.

Another benefit to LTE networks, adds Vukovic, is LTE networks themselves can be incorporated

into a SMART electrical grid system, which can manage energy use more efficiency and cost effectively, and tap into wind or solar energy when it's available.

CRC test network can verify new NGN technologies

As part of its mandate, CRC provides expert advice to Industry Canada, supports government operations for special events (e.g. G8, G20, Olympic Games), and designs guidelines and rules that companies can, in turn, use to develop next generation equipment and networks. As such, it is well positioned to collaborate with carriers and manufacturers to co-develop proofs of concept for new systems.

To test new concepts and technologies, clients can access a 7 km wireless test network in Ottawa, developed as part of CRC's WISELAB, to verify interoperability between the next generation networks and legacy networks (e.g. HSPA+), as well as the performance, range, scalability and quality of service for any new fixed or mobile technologies.

"Companies often seek to work with us because, as a government lab, we're recognized as independent technology-neutral developers who can verify these new technologies with a real network, and provide technical advice," says Vukovic "That makes it easier for companies to sell their technologies because the results performed are done by an independent research organization."

CRC is recognized globally for its expertise in developing and testing new wireless technologies for its government clients, and in licensing those technologies to companies within Canada and around the world. It is developing several technologies that can be used as building blocks for NGNs. Licences for its software defined radio, developed for Canada's military and public safety communities, are already being sold worldwide.

A Next Generation Network Primer

Globally, carriers plan to spend billions of dollars to deploy NGNs. Japan is poised to be an early adopter of the technology, followed by the United States and parts of Europe. Major service providers in Canada have announced plans to rollout LTE-ready networks starting in 2012.

Based on an Internet Protocol platform, LTE and WiMAX hold the promise of affordable broadband and faster speeds (100 Mbps download and 50 Mbps upload speeds) and greater efficiency than most advanced 3G networks. It's the ultimate converged network, offering voice, data, video-streaming, bandwidth-intensive applications and even high definition broadcasting on mobile devices.

CRC has also made significant advances in smart antennas to reduce energy consumption and increase system efficiency and transmission distances, particularly in high density urban areas.

"CRC looks at what's happening around the world and directs its research to address challenges in rolling out NGN in Canada. As a byproduct, we can help Canadian companies take advantage of these opportunities."

For more information contact Alex Vukovic, Vice-President, Terrestrial Wireless Systems Research branch at 613-998-2452 or *alex.vukovic@ic.gc.ca*.

2D-to-3D conversion – companies begin bridging the content gap with CRC technology

With the holiday season fast approaching, early adopters may be weighing the possible purchase of a 3D television with the limited content currently available.

For the industry, converting existing 2D content is an attractive option, since capturing 3D video

is complicated and costly. What's more, the conversion process can afford opportunities to manipulate images that capturing does not.

The Communications Research Centre (CRC) is offering 2D-to-3D conversion technologies to companies interested in bridging the content gap. Three companies currently have non-exclusive agreements with CRC.

Under a commercial license agreement, one Canadian company is integrating CRC's real-time 2D-to-3D conversion capability into a chip for the mobile phone manufacturer market.

"They are implementing our set of algorithms into a chip, so real-time conversion is done with no human intervention," explains Dr. Carlos Vázquez, research scientist in CRC's Advanced Video Systems group. "The quality and the processing requirements fit very well with cell phone devices."

Real-time 2D-to-3D conversion

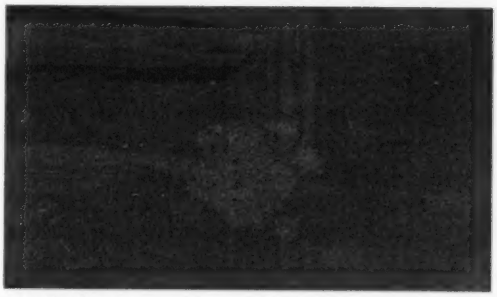
CRC-i3D uses patented colour-based surrogate depth maps (CSDM) for real-time 2D-to-3D conversion when applied to a media player. Two dimensional images contain 3D cues. CRC-i3D capitalizes on these cues, and exploits characteristics of the human visual system to create an impression of depth with artificial depth images. It uses depth image-based rendering to process pixel shifts, smooth edges and fill in holes. CRC-i3D can be tailored: the amount of depth and the position of the scene in the depth dimension are among the factors that can be customized.

CRC-i3D is ideal for devices with little processing power, such as cell phones and television sets. The resulting stereoscopic 3D images are comfortable to view.

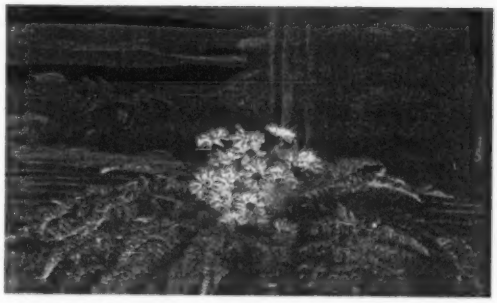
Off-line depth map manipulation

The CRC-Depth Map Editor and Generator (DMEG) is a software tool for off-line creation and manipulation of customized depth maps. It also uses CRC-CSDM. In the absence of a depth map, 3D producers can use CRC-DMEG to generate a surrogate. The software also allows users to interactively modify depth maps by providing immediate feedback through stereoscopic 3D visualization. Once a user is satisfied with the resulting depth map, the customized adjustments can be applied to all frames of a video sequence with one press of a button.

Original colour image



Initial depth map



Customized depth map

Two firms interested in offering 3D production services are testing CRC's off-line conversion software tool to determine if it meets their needs.

"The beauty of the technology transfer agreements," says Jeet Hothi, Director, Technology Transfer Office, "is that not only do they de-risk this new technology, they also provide a tremendous competitive advantage to the Canadian companies through patent protection."

For more information on CRC's 2D-to-3D conversion technologies contact Demin Wang, Research Manager in CRC's Advanced Video Systems section, at 613-991-5621 or *demin.wang@crc.gc.ca.*

CRC active at VTC2010-Fall

The Communications Research Centre (CRC) served as a collaborative partner in the IEEE Vehicular Technology Conference, held in Ottawa from September 6 to 9, 2010. In the wake of the four day VTC2010-Fall, General Chair Dr. Halim Yanikomeroglu shared the positive feedback he received with the CRC.

"One very senior member of the IEEE community wrote me stating, 'This is the best VTC I have attended since 1999,'" Yanikomeroglu proudly reported in a note to some CRC executives after the event.

The Carleton University professor went on to thank CRC for the great support it provided to the organization of the conference that attracted over 600 international delegates. Involvement extended from President Veena Rawat's service on the advisory committee, to the support of research staff who volunteered on-site.

"Alex's plenary speech was a pivotal event in the conference," said Yanikomeroglu, referring to the remarks of Dr. Alex Vukovic, Vice-President of CRC's Terrestrial Wireless Systems Research branch. His talk, "Wireless Communications for Intelligent Transportation Systems," was one of four plenary presentations.

Intelligent transportation systems (ITS) encompass efforts to add information and communications technology to transport infrastructure and vehicles. The resulting wireless systems must be built to compensate for the many factors inherent in motion.

Vukovic's speech centered on potential ITS applications, challenges of implementation of ITS, as well as potential solutions based on cognitive femtocells – technology CRC is developing. Femtocells are small cellular base stations that ease the drain on capacity when multiple mobile devices are used locally.

CRC researchers chaired several components of the conference, including Li Li who co-chaired the Ad Hoc and Sensor Networks track. Over a dozen papers presented throughout the packed program were authored or co-authored by CRC experts, including Andre Brandao, whose paper was presented at the Green Wireless Communications and Networks Workshop.

A group of delegates added a tour of CRC to their agendas. Demonstrations included channel sounding, CRC's cognitive radio learning platform, its coverage prediction software and 2D-to-3D conversion capabilities.

"I talked with one of the CRC tour attendees who said the tour was just awesome," noted Yanikomeroglu.

Mobile channel sounding measurements

CRC research scientist Dr. Yvo de Jong demonstrated a channel sounding system and data processing method designed to estimate key channel characteristics of the 4.9 GHz band, which is designated for public safety communications. The equipment includes a transmitter housed in a trailer that remains fixed for the experiment, and a receiver housed in a vehicle that can capture continuous measurements while mobile. A four-sided antenna array mounted on the roof of the vehicle measures multipath characteristics including Doppler shift

Dr. Yvo de Jong (left) explains equipment mounted on vehicle for channel sounding study. Users of the 4.9 GHz band for public safety, and others interested in learning more can contact Yvo de Jong at ***yvo.dejong@crc.gc.ca*** *or 613-990-9235.*

and direction-of-arrival, while a panoramic video camera, mounted on top of the antenna, captures images of the environment.

After the measurements are captured inside the vehicle, de Jong crunches the numbers in his office and cross references them with the panoramic images for a more complete picture of the data. A loss in signal, for example, could coincide with passing an obstacle along the route.

De Jong showed VTC visitors results from measurements taken on the CRC campus in a configuration resembling an emergency situation, with a command-post vehicle parked outside a building and a mobile unit driving along a road in front of that building.

CRC-Coral: a cognitive Wi-Fi networking system

CRC research manager Dr. John Sydor walked visitors through the workings of Coral – CRC's cognitive radio learning platform available for license. An ensemble of hardware and software, Coral is a unique combination of cognitive radio and Wi-Fi technologies that enables sensing of Wi-Fi environments widely used today.

"The platform is amenable to being manipulated," says Sydor, explaining the workings of Coral to fellow researchers – one of Coral's target audiences.

Periodically, the network management station polls the network nodes and returns this information to the database. When the database flags interference, for example, the network management station informs the cognitive engine, which can compute new parameters for the wireless network. The application programming interface tweaks different controls in the network to minimize interference and optimize bandwidth.

Companies exploring new products that optimize the operation of a wireless network can also capitalize on Coral. Its network configurations and applications are numerous: mesh or relay configurations; rural, sensor or enterprise networking applications. The technology allows investigation of issues that are important to future cellular and wireless access systems.

Dr. John Sydor introduces VTC visitors to Coral – CRC's cognitive radio learning platform. For more information, visit ***www.crc.gc.ca/coral*** *or contact John Sydor at 613-998-2388 or* ***john.sydor@crc.gc.ca.***

Other stops on the tour

The ability of CRC-COVLAB software to calculate coverage anywhere in the world impressed the group of international visitors. Once provided with parameters specific to the transmission of the signal, such as transmitter locations and frequency, COVLAB can overlay coverage prediction with information from multiple databases, including population, topography and morphology.

In response to countless requests for channel sounding services over the years, research scientist Dr. Robert Bultitude worked with an Ottawa equipment manufacturer to develop a low-cost system, so systems organizations can employ their own channel sounder for scenario-specific measurements to verify and support system modelling and problem identification. VTC visitors saw the system used for dynamic sounding of all three links in a relay channel configuration, set up to provide in-fill in the shadow area behind a building.

In CRC's Advanced Television Evaluation Laboratory, visitors were introduced to CRC's 2D-to-3D conversion capabilities. They also previewed next generation 3D-TV which does not require special glasses.

News and Awards

In Canada for the first time: Recent Advances in Intrusion Detection (RAID) and Visualization for Cyber Security (VizSec)

Over 200 registrants representing more than 20 countries attended the cyber security conferences RAID, VizSec and Technology Watch, co-hosted by the Communications Research Centre (CRC) and Defence R&D Canada (DRDC). The mid-September conferences, held in Ottawa, were a success for the local organizing committee, which included CRC's Dr. Mathieu Couture and Frederic Massicotte. Couture and Massicotte were proud of the results: the conference unfolded according to plan, delegates delivered positive reviews, and they – both network security researchers – gathered ideas for advancing their work in new ways.

"The three events were an excellent opportunity for Canadian researchers and practitioners, who represented more than 40 percent of the total number of delegates, to get in touch with internationally renowned cyber security experts," said Massicotte.

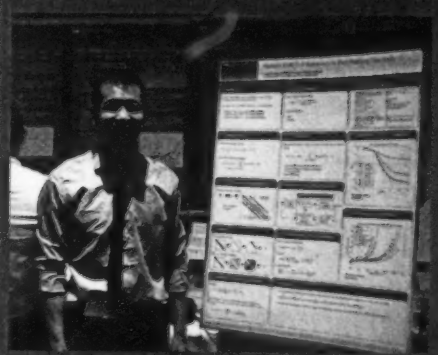
CRC booth at VTC2010-Fall

Several research groups showcased their work at the CRC booth.

Digital audio broadcasting (DAB), its upgrade (DAB+), digital multimedia broadcasting (DMB), and digital video broadcasting-terrestrial (DVB-T) are becoming increasingly common in many parts of the world. With this, CRC's advanced audio systems group demonstrated a sophisticated DAB/DMB/DAB+ receiver that mitigates the Doppler effect at increase vehicle speeds, thereby improving DAB/DMB/DAB+ services broadcast at L-band (1452-1492 MHz). The team also presented technology capable of bringing mobility to DVB-T systems which are deployed mainly for fixed home reception.

The combined expertise of CRC's advanced video systems team and its television networks and transmission team presented research using their Advanced Television Systems Committee (ATSC) mobile TV test bed.

"People were interested in understanding the system deployment challenges including single frequency network configuration and optimization of mobile TV quality," says Dr. Omneya Issa, research scientist in the advanced video systems group. "We had the chance to talk to representatives from different sectors – government, industry and academia. Some of these discussions are promising in terms of possible collaborations."



Dr. Zhihong (Hunter) Hong of CRC's Advanced Audio Systems group showcased the team's research at the VTC2010-Fall exhibit.

"Since a quarter of the Canadian attendees were students, the conferences also helped forge the future of cyber security in Canada," said Couture.

This, the 13th RAID and 7th VizSec, marked the first time these prestigious cyber security conferences were held in Canada. The Technology Watch component was dedicated to exploring real world problems driving cyber security research.

Best paper award for CRC research scientists

"Distributed Selection of Sensing Nodes in Cognitive Radio Networks," presented by CRC research scientist Dr. Kareem Baddour, received a best paper award at the 2010 International Symposium on Wireless Communications Systems.

Drs. Oktay Ureten and Tricia Willink co-authored the winning paper with Baddour. Baddour, Ureten and Willink work in the Radio Communications Technologies section of CRC's Terrestrial Wireless Systems Research branch.

The symposium took place in York, England from September 19 to 22.

A paper co-authored by Drs. Oktay Ureten (left), Kareem Baddour (right) and Tricia Willink (not pictured) received a best paper award at the 2010 International Symposium on Wireless Communications Systems.

FP7 is the European Union's Seventh Framework Programme – a concerted approach to funding research in Europe, including research in Information and Communication Technologies (ICT). The CRC is the Canadian National Contact Point for ICT under FP7. Canadians interested in learning more about ICT research opportunities under FP7 should contact CRC's Business Development Office:

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www.crc.gc.ca/en/html/crc/home/partners/ncp/ncp

CRC's mission is to be the federal government's centre of excellence for communications R&D, ensuring an independent source of advice for public policy purposes. CRC also aims to help identify and close the innovation gaps in Canada's communications sector by:

- *engaging in industry partnerships;*
- *building technical intelligence;*
- *supporting the information and communications technologies industry.*